

UNITED STATES PATENT APPLICATION

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for

**AN INSTRUMENT THAT CAN BE INSERTED INTO THE HUMAN BODY**

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## **AN INSTRUMENT THAT CAN BE INSERTED INTO THE HUMAN BODY**

### Related Applications

[0001] This patent application is a divisional of currently pending U.S. Patent Application No. 08/946,799, filed October 8, 1997, which is a Continuation of U.S. Patent Application No. 08/530,150, filed September 29, 1995, now abandoned.

### Field of the Invention

[0002] The present invention relates to an instrument that can be inserted into the human body, this instrument being provided with at least one channel for fluid and, in particular a gas, which is introduced into the inside of the body.

### Background of the Invention

[0003] By way of illustration in laparoscopic operations, it is usually necessary to introduce a fluid and, in particular a gas, such as by way of illustration CO<sub>2</sub> into the body cavity into which incision was made in order that the cavity does not collapse due to the "external pressure".

[0004] With increasing duration of the operation, the number of incisions as well as the frequency of changing the instruments requires not only large amounts of insufflation gas, but also high insufflation rates. This is especially the case in HF surgery and laser treatment in which the gas has to remove additionally occurring smoke, etc. In the past, flow rates of a few liters per minute used to suffice, however, for some time increasingly higher flow rates are demanded.

[0005] However, even at flow rates in the 5 to 7 l/min range, the patient suffers hyperthermia, i.e. a local drop in temperature distinctly below the body temperature.

If (insufflation) devices having even higher outputs, which in the case of the devices that are available on the market reaches up to 15 l/min, or even insufflation devices having flow-through rates up to 40 l/min are employed, as described in the patent literature, the problem of hyperthermia is even more serious than with conventional devices.

[0006] Therefore, it has been suggested to provide a means of heating the fluid in the insufflation device. In particular, with gas insufflation devices there is the problem of heating the gas in the insufflation device, because the gas has little thermal capacity, it cools off again in the supply tube on the way to the patient.

[0007] Thus, whenever the gas is heated only in the insufflation device, it is necessary to heat the gas to a higher temperature than is actually desired in order that the gas enters the human body "just" at a temperature that corresponds to the body temperature (37°C). However, this has the drawback that the inertia of the system due to the long tube usually required is large if deviations of the temperature from the desired temperature, i.e. the control constant, is large and therefore the temperature constancy is small due to normal fluctuations. The gas therefore may even be introduced at a too high temperature inside the body.

[0008] In another attempt to solve the problem of the patient's hyperthermia, notably a device sold by Wisap, Sauerlach under the name "Flow-Therme" uses an

additional heatable tube that connects the actual insufflation device to the instrument to be inserted into the human body.

[0009] This solution attempt, too, does not ensure optimum temperature control, because the control constant is large due the length of the tube and the possibly strongly varying surrounding conditions along the tube. Moreover, a heatable tube is less pliant and heavier due to the integrated heating means than a normal tube. Thus, it is not as easy to handle as a normal tube.

#### Summary of the Invention

[0010] The object of the present invention is to ensure in introduction of at least one fluid and, in particular at least of a gas, into the body, excellent temperature control and, in particular, constancy of temperature of the fluid introduced into the body and, in particular, of the introduced gas.

[0011] An element of the present invention is that the instrument is provided with a heating means for the fluid. The heating means can heat the fluid and, in particular the gas, alone or in addition to a heating means in the insufflation device as well as, if need be, to a "supporting" heating means in the insufflation tube. Preferred at any rate is if the heating means of the instrument "assumes" "control" of the control procedure.

[0012] Disposal of the heating device in the, or immediately before the, human body, notably in or near the instrument utilized in the human body, ensures that optimum temperature control with short control constants can occur in such a manner that the

fluid, that is the rinsing fluid or preferably the gas, having excellent constancy of temperature is introduced into the body cavity.

[0013] Another advantage of the invented instrument is that the instrument is heated by the heating means itself as well as by the heated fluid. This prevents the instrument and, in particular, an endoscope optics disposed therein, from fogging up. It is especially advantageous if the heating means surrounds that part of the instrument that accommodates the optical system of the system and, in particular of an endoscope, because this ensures optimum heating not only of the fluid but also of the "sensitive" parts of the instrument.

[0014] Furthermore, a conventional supply tube of any length, in particular, a length that can be varied from application to application can be utilized between the insufflation device and the instrument.

[0015] According to certain embodiments, the heating means can be integrated into the instrument itself. This design has not only the advantage that the optics located in the instrument are, if need be, heated directly along with the instrument, but also, which is not apparent at first glance, that it improves the balance of the weight of the instrument.

[0016] Although one usually tries to design the instruments as lightly as possible, this principle is not adhered to with laparoscopes utilized in conjunction with a CO<sub>2</sub> laser. In order to compensate for the weight of the CO<sub>2</sub> laser or the arm connected to

this laser, the instrument has to be designed heavier than usual. This requirement can be easily met by building the heating means into the instrument.

[0017] As an alternative, the heating means can be disposed in a separate housing which is provided with a fluid inlet and a fluid outlet which is connected via a short piece of tube to the proximal fluid inlet of the instrument itself. This design not only prevents undesirable top-heaviness in specific applications, but also permits easy upgrading of already existing instruments in such a manner that they functionally comply with the instrument proposed by the present invention.

[0018] The use of an electric heating coil and its special design in accordance with certain embodiments is now described.

[0019] In the aforementioned alternative, in which the heating means is disposed outside the body, it is preferable if the heating means is provided in the part of the instrument which remains outside the human body. This permits accommodating the heating means as well as parts of the control unit in the thicker than usually designed proximal part of the instrument without impairing the functions of the instrument.

[0020] Another alternative which is suited particularly for existing instruments is now set forth. The heating means is provided in a separate housing which is connected in one piece to the conventionally designed instrument. This alternative permits upgrading existing instruments as well.

[0021] In certain embodiments, the heating means is provided with at least one temperature sensor whose output signal is applied to a control means which controls the power delivered to the heating means, thereby permitting not only control of the heating output but also control of the set temperature.

[0022] In another embodiment, there are provided at least two temperature sensors whose output signals are compared for checking the function of the temperature sensors, thereby permitting relatively precise detection of malfunctions.

[0023] It is advantageous if the temperature sensor or sensors are disposed as close as possible to the channel through which the fluid flows. Independent of the exact design of the temperature sensors, it is advantageous if a temperature sensor which can release a safety circuit is disposed as close as possible to the distal end of the instrument.

[0024] Many different evaluation algorithms can be used to control the invented instrument. These strategies can be stored in a program memory and called up upon demand. In any event, any instrument and, in particular, a trocar as well as an as such known laparoscope for surgical applications can be employed in conjunction with the present invention.

#### Brief Description of the Drawings

[0025] The present invention is made more apparent in the following by way of example without the intention of limiting the scope or spirit of the overall inventive idea using preferred embodiments with reference to the drawings to which are

explicitly referred for the disclosure of all invented details not explained more closely herein.

[0026] Fig. 1 shows a lateral view of a first preferred embodiment of an invented instrument,

[0027] Fig. 2 shows a section at I—I in fig. 1,

[0028] Fig. 3 shows a variant of the preferred embodiment depicted in fig. 1,

[0029] Fig. 4 shows another variant of the preferred embodiment depicted in fig. 1, and

[0030] Fig. 5 shows a second preferred embodiment of the present invention.

#### Detailed Description of an Embodiment of the Invention

[0031] Fig. 1 shows an instrument which can be inserted inside a human (or animal) body and which, without limiting the scope and spirit of the present invention is an as such known trocar 1 having a distal end 1' and a proximal end 1". The trocar has a cavity 2 extending in the longitudinal direction. Into this cavity 2 (by way of illustration) not depicted endoscope optics can be inserted in such a manner that additionally a channel (having a ring-shaped cross section) is formed for a fluid and, in particular, a gas such as CO<sub>2</sub>. Of course, another channel separated from the other insertable instruments may be provided for the to-be introduced fluid.



[0032] For the introduction of a gas in the channel formed by inserting an instrument or an already existing channel, a connection 3 is provided, which by way of illustration can be a conventional luer-lock connection or a tube nozzle, which connection 3 is provided with a cock 4. In the case of large flow-through rates, a connection having a larger diameter than the one which is usually used in a trocar can also be employed.

[0033] For heating the cold gas or the gas already preheated by a heating means in a not depicted insufflation device, which is joined via a tube to connection 3, a heating means 5 having a connection 5' is provided. This heating means has at least one electric heating coil 6, which surrounds the channel through which the fluid is conducted. In the shown preferred embodiment, the heating means 5 is provided in the "thicker" part of the trocar, which remains outside the human body.

[0034] Furthermore, the heating means 5 is provided with at least one temperature sensor 7, whose output signal is applied to a not depicted control or adjustment means which controls the electric power applied to the heating coil 6. Preferably, at least two temperature sensors are provided whose output signals are compared for checking the function of the temperature sensors. The temperature sensor or sensors should be disposed as close as possible to the channel through which the fluid flows. Thus the control constants are small even in the case of high flow rates up to 40 l/min and more as well as of greatly varying flow rates.

[0035] In the following figures, the same reference numbers stand for the same respectively similar parts, obviating renewed introduction.

[0036] Fig. 3 shows a partial section of a top view of a modification of the preferred embodiment depicted in figs. 1 and 2. In this preferred embodiment, the heating means is accommodated in a lateral addition. The heating coil 6 is designed cube-shaped and disposed in the channel which joins the connection 3 including cock 4 to the cavity 2 in the instrument and 9 stands for a casting compound.

[0037] Fig. 4 also shows a partial section of a top view of a further modification of the preferred embodiment depicted in figs. 1 and 2. In this modification, the heating coil is designed as a flat, electric heated element.

[0038] Fig. 5 shows a partial section of a top view and a lateral view of a second preferred embodiment of the present invention. In this preferred embodiment, the heating means is not accommodated in the instrument itself, but rather in an addition which is provided with a housing 11 which is provided with a tube nozzle 4' which functions as an inlet and a tube nozzle 4'' which functions as an outlet. The addition is connected to the inlet 3 of the instrument not depicted in fig. 5 by means of the tube nozzle 4'' and a short tube. Located in the housing 11 is a fluid channel in which the heating coil designed as a flat element is disposed and 5' stands for the connection for the heating means.

[0039] In the preceding the present invention has been described using a preferred embodiment without the intention of limiting the scope and spirit of the overall invention. By way of illustration, a heating means operating with a heat exchanger can be employed instead of an electric heating means.

[0040] Of course, the design of the heating coils is not restricted to the preferred embodiments described in the preceding, but rather many different radiators can be employed which, by way of illustration can be designed as a "tubular heating element".

[0041] The instrument which in accordance with the present invention is equipped with a heating means is also not restricted to the explicitly mentioned trocars and laparoscopes described in the preceding.